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INFLUENCE OF STORAGE CONDITIONS ON QUALITY PARAMETERS OF POMEGRANATE FRUITS STORED IN DIFFERENT PACKAGING MATERIALS

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ABSTRACT

For shelf-life extension of pomegranate fruits, modified atmospheric storage at ambient conditions and 10^{O} C was studied. Fruits were stored in 200, 300 gauge HDPE and silicone membrane packages. Gas composition inside the package, texture, colour and overall quality parameters were evaluated at these two storage temperatures. In ambient storage, the shelf-life of pomegranate fruit was 10 days whereas in modified atmosphere packaging (200 gauge HDPE, 300 gauge HDPE and silicone membrane system), the shelf-life of pomegranate fruits was extended up to 60, 60, 25 days at ambient and 96, 96, 65 days at 10^{O} C temperature respectively.

KEYWORDS: Silicon Membrane Packaging, Pomegranate, HDPE Packaging, CAP, Shelf Life

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INTRODUCTION

Pomegranate (*Punica granatum* L.) is the fruit crop which belongs to a family *Punicaceae* Pomegranate is popularly known as Anar, Dalimb, Chinese apple and Granada, Granade. It is grown extensively in India, Pakistan, Afghanistan, Iran, Saudi Arabia and in the subtropical areas of South America.

In India, it is commercially grown in Karnataka, Maharashtra, Gujrat, Rajasthan, Tamil Nadu and Andhra Pradesh states. Pomegranate varieties grown in India are Bhagawa, Ganesh, Mrudula, Arakta, Alandi or Vadki, Badana, Dholaka, Kandhari, Kabul, Muskat Red, Paper Shell, Poona, Spanish Ruby, Vellodu etc. In India, area under pomegranate cultivation is around 1,12,000 ha producing about 7.93 lakh tons of pomegranate fruits per annum. In Karnataka state, the area under pomegranate is around 12,700 ha producing about 1,24,009 tons of pomegranate fruits per annum with a productivity of 9.8 metric ton per ha (Chamber *et al*., 2005).

Pomegranate, being a non-climacteric fruit has tremendous potentiality for modified atmosphere packaging (MAP) by using polymeric films which will not only retain fruit quality during storage but also help in prevention of chilling injury during refrigerated transport and storage. Therefore, an integrated approach on both production and post harvest management using recent technologies *viz*., individual shrink wrapping, waxing, controlled atmosphere (CA) storage coupled with judicious temperature management practices needs more attention for wide distribution of this delicious fruit in the global market (Roy and Waskar, 1997).

Original Article

Research in post harvest technology of fresh fruits and vegetables has shown that proper control of temperature, relative humidity and manipulation of storage gas composition in modified/controlled atmosphere (MA/CA) storage systems in addition to harvesting at optimal maturity stage, minimization of injury during handling and reduction in post harvest microbial infection, can successfully extend the shelf life thus minimize the extent of post harvest losses (Raghavan and Gariepy, 1985; Kader, 1992). The most commercially used technique for altering gas composition is the membrane system. This consists of a membrane of differential permeability (such as silicone) to gas as part of the enclosure walls of an air tight storage chamber.

The post harvest losses in pomegranate occur due to lack of proper packaging material and improper handling during long transport. Extension of shelf life can be possible by checking the rate of respiration, transpiration and microbial infection.

MATERIALS AND METHODS

The present investigation entitled "Studies on shelf life extension of pomegranate (*Punica granatum* L.)" cv. Bhagawa was undertaken in the laboratory of All India Coordinated Research Project on Post Harvest Technology, UAS, GKVK, Bangalore, For this experiment healthy, matured and near to export quality pomegranate fruits of Bhagawa variety were procured from commercially cultivated pomegranate orchards. The fruits were harvested one day before experimentation.

The pomegranate fruits were washed thoroughly in running water, drained and dipped in 0.2 % Bavistin for 1 minute and surface dried (Dhumal *et al.*, 1984).

Studies on Packages

Modified atmosphere packages using HDPE and PET jars with silicone membrane were studied for the storage of pomegranate with a focus to enhance its shelf life.

Experimental Details:

The experiments were carried out with 10 treatments replicated three times using Completely Randomized Design (CRD).

Treatment Details

- **T_1:** 200 gauge HDPE package without ventilation
- **T_2:** 200 gauge HDPE package with 0.06 % ventilation
- **T_3:** 200 gauge HDPE package with 0.1 % ventilation
- T_4: 300 gauge HDPE package without ventilation
- **T_5:** 300 gauge HDPE package with 0.06 % ventilation
- **T_6:** 300 gauge HDPE package with 0.1 % ventilation
- **T_7:** Silicone membrane with 1 cm^2 window area
- **T_8:** Silicone membrane with 2 cm^2 window area

- **T_9:** Silicone membrane with 3 cm^2 window area
- **T_{10}:** Control

Packaging and storage studies on above treatments were carried out under ambient and refrigerated environments to enhance the shelf life of pomegranate fruit.

- Ambient temperature (25-27^o C)
- Refrigerated condition (10^o C)

Quality Parameters of Pomegranate

- **Firmness**

For measuring the firmness of fruit, the penetrating force was measured by using a fruit pressure tester and it was expressed as kg/cm^2.

- **Physiological loss in weight**

For determining physiological loss in weight (PLW), weight of fruits with package was recorded using electronic balance at periodic intervals. The PLW was computed from the difference in fruit weight from first day to the subsequent day. The PLW was expressed in percent either on daily or on cumulative basis from one period to the other. Physiological loss in fruit weight was calculated using the formula:

$$PLW\ (\%) = \frac{Initial\ weight - Weight\ after\ known\ storage\ period}{Initial\ weight}\ X\ 100$$

- **Total Soluble Solids (TSS)**

The total soluble solids of pomegranate juice samples were recorded in ^{O}Brix by using a Hand Refractometer (Erma Optical Works Ltd., Japan) after making necessary temperature corrections.

- **Total Sugars**

The total sugar is estimated by taking 50 ml of the clarified solution (prepared for reducing sugar estimation) was taken in 100 ml volumetric flask. A 2-3 spatula of citric acid was added to it and left for 24 hours.

10 ml of Fehling's solution [Fehling's No.1 (5 ml) + Fehling's No.2 (5 ml)] with 25 to 50 ml of distilled water was taken in a conical flask, heated to boil and titrated against the sample prepared using methylene blue as an indicator. The end point of titration was formation of brick red colour.

Calculation

$$Total\ sugars\ (\%) = \frac{0.05\ X\ Dilution}{Titre\ value\ X\ Weight\ of\ sample}\ X\ 100$$

- **Reducing Sugars**

For estimation of reducing sugar 100 g arils were taken and juice was extracted by blending with 100 ml distilled water in a mixer followed by filtration. Then, the juice was transferred to 250 ml volumetric flask and volume was made upto 250 ml. then 10 ml of this sample was taken in a volumetric flask and neutralized with 1 N NaOH. To this, 2 ml of 45 per cent lead acetate solution was added, shaked well and allowed to stand for 10 minutes. Then necessary amount of 22

per cent potassium oxalate was added to remove the excess lead present and the volume was made up to 100 ml with distilled water. The solution was filtered through Whatman No. 4 filter paper and the filtrate (clarified solution) was used for analysis.

10 ml of Fehling's solution [Fehling's No.1 (5 ml) + Fehling's No.2 (5 ml)] with 25 to 50 ml of distilled water was taken in a conical flask, heated to boil and titrated against the clarified solution using methylene blue as an indicator. The end point of titration was formation of brick red colour.

Calculation

$$Reducing\ sugars\ (\%) = \frac{0.05\ X\ Dilution}{Titre\ value\ X\ Weight\ of\ sample}\ X\ 100$$

- **Non Reducing Sugars**

The non reducing sugar contents of the pomegranate juice samples were determined by the method of difference as:

Non reducing sugars = Total sugars - Reducing sugars

- **Total Titrable Acidity**

The total titrable acidity of pomegranate juice sample was determined by visual titration method (Ranganna, 1986), as narrated below.

100 g of arils were taken, juice was extracted and filtered. Then its volume was made upto 250 ml with distilled water which was used for estimation of titrable acidity. 10 ml of diluted juice was taken in a conical flask with 20 ml distilled water and titrated against 0.1N NaOH solution using 1 or 2 drops of phenolphthalein indicator. Formation of pink colour was taken as the end point of titration. Then, the acidity, expressed as the percentage of anhydrous citric acid, was calculated as shown:

$$\text{Titrable acidity (mg \%)} = \frac{\text{Titrable value X N of NaOH X Volume made up X Equivalent weight of citric acid}}{\text{Volume of sample taken for titration}}$$

- **Ascorbic Acid**

Ascorbic acid content of pomegranate juice samples was determined by Colorimetric analysis. Ascorbic acid was first dehydrogenated by bromination. The dehydrogenated ascorbic acid was then treated with 2, 4-DNPH to form osazone crystal and dissolved in H_2SO_4 to give orange-red coloured solution whose optical density was measured at 540 nm.

Different aliquots of standard dehydro ascorbic acid solution (0.2 to 1 ml) was taken in a series of test tubes. Similarly, different aliquots of (0.1 to 0.2 ml) of brominated sample extracts were also taken. Volume was made upto 3 ml using water in the test tubes. Then, 1 ml of DNPH reagent followed by 1 to 2 drops of thiourea was added to each test tube. After mixing the test tubes were incubated at 37 ^{O}C for 3 hrs in a water bath. Then 7 ml of 80 % 100 ml H_2SO_4 was added to each test tube to dissolve orange-red osazone. Optical density of different aliquots of standard ascorbic acid and sample were recorded by setting blank for zero O.D. Then, standard graph was obtained by plotting O.D. values vs. concentration

of vitamin C solution. From the standard vitamin C curve, vitamin C content of the sample was estimated.

RESULTS AND DISCUSSIONS

Influence of different packages on quality parameters of pomegranate fruits stored in ambient temperature and refrigerated condition are as follows.

- **Firmness (kg/cm^2)**

To find firmness of pomegranate fruits, fruit pressure tester was used. From Table.1, it shows that the fresh pomegranate fruits showed maximum firmness of 13.16 kg/cm^2. In ambient condition, treatment T_1 (200 gauge HDPE package) showed maximum firmness value (12.26 kg/cm^2). After $T_{1,}$ T_2 showed firmness value as 11 kg/cm^2 followed by T_3 (9.83 kg/cm^2) after 60 days under MAP followed by 7 days in ambient conditions and T_9 indicated the minimum value (9.16 kg/cm^2).

In case of packages stored under refrigerated condition (Table.2), maximum firmness value was observed in case of T_1 (12.5 kg/cm^2). After $T_{1,}$ T_2 showed firmness value as 11.06 kg/cm^2 followed by T_3 (10.06 kg/cm^2) after 96 days under MAP followed by 7 days in ambient conditions and T_9 indicated the minimum value (9.00 kg/cm^2).

- **Physiological Loss in Weight (%) of Pomegranate Fruits**

The PLW (%) of pomegranate fruits stored in ambient condition are as shown in fig 1. Among all the treatments the least PLW (%) was observed in case of silicone membrane, T_7 (4 per cent) and T_3 (9 per cent) shown the highest PLW (%).Further, the results of the statistical analysis were found to be significant after 60 days under MAP followed by 7 days in ambient storage. PLW (%) of control was observed as 11 per cent on 10th day of its storage.

The PLW (%) of pomegranate fruits stored at 10^O C are presented in Fig.2 Waskar *et al*., (1999) also found that during pomegranate storage, PLW was increased along with storage period at room temperature but the increase was slow at low temperature. From Fig. 2, in silicon membrane T_7 showed least PLW (%) value as 14 per cent followed by T_8 (4 per cent) and highest value observed in T_3 (14 per cent) and followed by T_2 (13 per cent) After 96 days under MAP followed by 7 days in ambient storage. Further, the results of the statistical analysis were found to be significant. PLW (%) of control was observed as 4 per cent on 10th day of its storage.

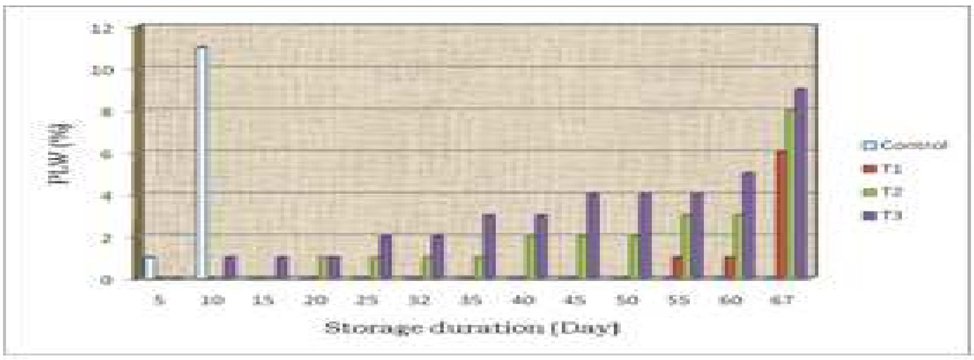

Figure 1: Effect of 200 Gauge HDPE Packages on PLW (%) of Pomegranate Fruits in Stored In Ambient Condition

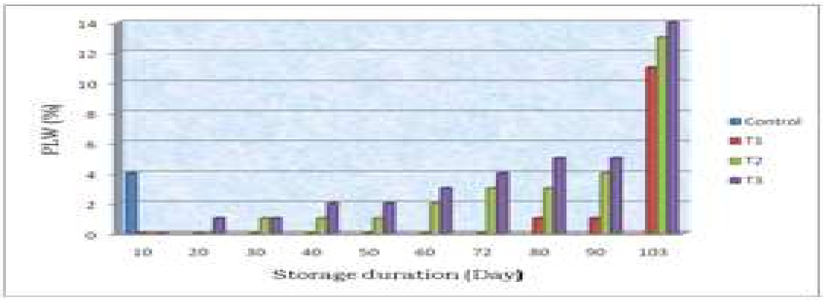

Figure 2: Effect of 200 Gauge HDPE Packages on PLW (%) of Pomegranate Fruits Stored at 10^0 C

- **Tss (^{O} Brix)**

The pomegranate fruit stored at both ambient and 10^O C temperatures among the packages showed a marginal increase in total soluble solids (Tables 1 and 2). Where fruits in advanced stage of ripening present the highest levels of soluble solids (Lyon *et al*., 1992).

Also, increase in TSS during ripening may result from an increase in concentration of organic solutes as a consequence of water loss (Ryall and Pentzer, 1982). Increase in TSS may also occur due to numerous anabolic and catabolic processes taking place in the fruit, preparing it for senescence (Smith *et al*., 1979). The increase in TSS and sugars of pomegranate fruits could be attributed to conversion of starch and other insoluble carbohydrates into soluble sugars (McCombs *et al*., 1976).

TSS (^{O}Brix) of pomegranate juice was measured with hand refractometer. In case of fresh pomegranate fruits, the TSS for both ambient and 10^0 C storage condition, the maximum value observed in T_9 (19.33^O Brix and 19.50^O Brix) and minimum value was observed in T_1 (16.86^O Brix and 16.00^O Brix) respectively after 60 days under MAP followed by 7 days in both the storage condition.

- **Total Sugars (%)**

The total sugars of stored pomegranate fruits increased slightly in ambient and low temperature storage conditions irrespective of packages (Tables 1 and 2). Minimum total sugar value shown by T_1 as 12.33 and 10.50 per cent both in ambient and 10^O C storage conditions respectively. The maximum total sugar value shown by T_9 as 15.23 per cent at 10^O C storage and followed by T_6 (15.13 per cent) at ambient storage conditions. Fruits stored at low temperature showed significantly lower total sugar content increase than those at room temperature. This could probably be due to slower ripening rate at the low storage temperature.

- **Reducing Sugars (%)**

There was a considerable increase in reducing sugars of pomegranate fruits from 7.86 per cent (fresh) to minimally increased value T_1 as 9.96 and 8.23 per cent at ambient and 10^O C storage respectively (Table 1 and 2.). The increase in reducing sugars could be attributed to: (i). inversion of non reducing sugars in the pulp into reducing sugars which was also enhanced due to increase in acidity of pulp during storage, (ii). increase in total sugars due to hydrolysis of some polysaccharides into sugars. The storage at lower temperatures retarded the processes, which could be the cause of lower level of increase in reducing sugars in the pulp samples.

- **Non-Reducing Sugars (%)**

The non-reducing sugars were found to be decreased during pomegranate storage. Decrease of non-reducing sugars was from 2.43 per cent (fresh) to minimally decreased value shown by T_7 (2.6 per cent) and T_1 (2.26 per cent) under ambient and 10^O C storage conditions respectively.

- **Titrable Acidity (%)**

In both cases of storage conditions, titrable acidity of pomegranate fruits was found to be slightly decreased which is irrespective of packages used and storage temperatures as given in Table 1 and 2. Among the treatments the maximum titrable acidity was shown by the 200 gauge HDPE package, T_1 showed maximum titrable acidity as 0.60 per cent and followed by T_5 (0.55 per cent) in 300 gauge HDPE package, the minimum titrable acidity value was observed in case of T_9 (0.35 per cent) after 60 days under MAP followed by 7 days in ambient conditions.

In Case of 10 ^{0}C storage maximum titrable acidity was shown by the 200 gauge HDPE package, T_1 showed maximum titrable acidity as 0.62 per cent and the minimum titrable acidity value was observed in case of T_9 (0.30 per cent) after 60 days under MAP followed by 7 days. The decrease in acidity during ripening may be due to conversion of acids to sugars or it may be due to utilization of organic acid in respiratory process (Ulrich, 1970).

- **Ascorbic Acid**

The ascorbic acid content of pomegranate fruit minimally decreased from 13.16 mg/100 g (fresh) to 12.66 and 12.8 mg/100 g in T_1 at ambient and 10^O C storage conditions respectively. The reduction in ascorbic acid content might be due to the activity of oxidative enzymes during storage. However, the decrease in ascorbic content was observed in the present study, in most of the packages, may be due to the oxidative reduction of vitamin C in presence of molecular oxygen by ascorbic acid oxidase enzyme (Pruthi *et al.,* 1984).

Table 1: Quality Parameters of the Pomegranate Fruits Stored Different Packaging Materials at Ambient Temperature (27^0 C)

Treatment	Firmness (kg/cm^2)	TSS (%)	Total Sugars	Reducing sugars	Non-Reducing	Titratable acidity	Ascorbic acid
Fresh	13.16	15.33	10.3	7.86	2.43	0.64	13.16
Control	9.46	16.46	10.26	8.76	1.5	0.57	12.76
T_1	12.26	16.86	12.33	9.96	2.37	0.60	12.66
T_2	11	17.93	13.16	11.33	2.03	0.50	11.33
T_3	9.83	18.63	14.46	12.33	2.13	0.41	10.33
T_4	10.33	18.16	13.93	11.6	2.33	0.50	11
T_5	11.5	17.36	12.8	10.46	2.34	0.55	12.03
T_6	9.33	19.2	15.13	12.76	2.37	0.37	9.6
T_7	10.83	19	15	12.4	2.6	0.46	10.66
T_8	11.66	18.6	14.63	12.3	2.33	0.54	11.03
T_9	9.16	19.33	14.33	12.36	1.97	0.35	8.5
Mean	10.77	17.90	13.30	11.07	2.21	0.50	11.19
F test	*	*	*	*	*	*	*
SEM	0.14	0.12	0.10	0.00	0.00	0	0.08
CD at 5 %	0.42	0.35	0.30	0.00	0.00	0.01	0.25

***-significant**

Ns-non significant

Table 2: Quality Parameters of Pomegranate Fruits Stored Using Different Packaging Materials at 10^0c

Treatment	Firmness (kg/cm^2)	TSS (%)	Total Sugars	Reducing sugars	Non-Reducing	Titratable acidity	Ascorbic acid
Fresh	13.16	15.33	10.30	7.86	2.43	0.64	13.16
Control	10.33	18.73	13.86	10.50	3.36	0.51	12.20
T_1	12.50	16.00	10.50	8.23	2.26	0.62	12.80
T_2	11.06	17.03	11.20	8.93	2.26	0.59	11.86
T_3	10.06	18.06	12.70	10.90	1.80	0.46	11.16
T_4	10.50	17.50	11.83	10.13	1.70	0.53	11.16
T_5	11.83	16.46	10.83	8.70	2.13	0.60	12.43
T_6	9.50	18.50	13.06	11.83	1.23	0.41	10.60
T_7	10.06	18.50	14.36	12.24	2.12	0.35	8.10
T_8	11.33	17.66	12.30	10.23	1.83	0.40	9.50
T_9	9.00	19.50	15.23	14.10	1.13	0.30	7.33
Mean	10.85	17.57	12.38	10.33	2.02	0.49	10.92
F test	*	*	*	*	*	*	*
SEM	0.10	0.08	0.18	0.09	0.17	0.01	0.09
CD at 5 %	0.31	0.24	0.53	0.28	0.50	0.03	0.27

***-significant**

Ns-non significant

CONCLUSIONS

At the end of the storage studies, the biochemical properties such as TSS, total sugars, reducing sugars, non reducing sugars, titrable acidity and ascorbic acid content were evaluated to see the best treatment that enhances the shelf-life of pomegranate fruits retaining its quality as well as other sensory properties.

Among 200 gauge HDPE package treatments, T_1 was found to be better with regard to all the quality parameters studied. In 300 gauge HDPE package treatments, T_5 was found to be better with regard to all the quality parameters studied. In case of silicone membrane system treatments, T_8 was found better with respect to all quality parameters studied.

Among all the three treatments, 200 gauge HDPE package without ventilation (T_1) was found to be best treatment with regard to all quality parameters.

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